Extraction line design constraint and choices

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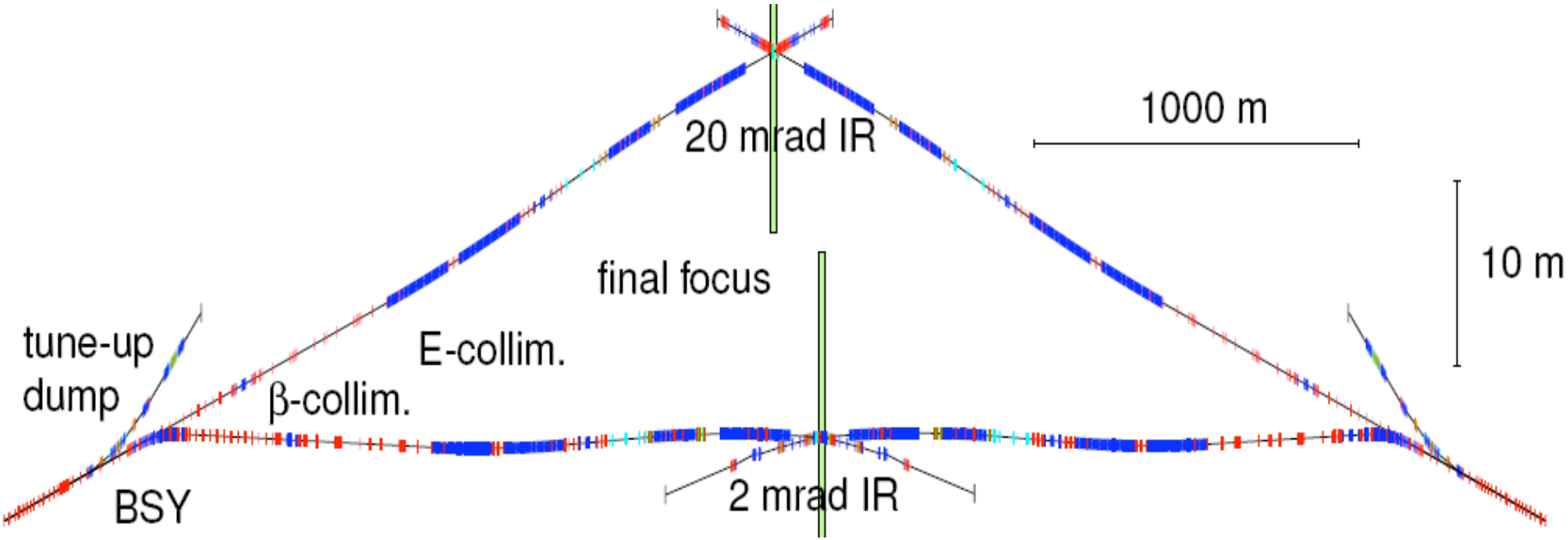
What do I mean?

- Small (and zero) crossing angle layouts are very challenging, due to
  - Beam conditions
  - Hardware and layout constraints
- We have some experience of the small crossing angle design evolution, which I'll review:
  - The fundamental challenges
  - Progress and problems with the Snowmass extraction line, developed by the 2mrad task force
  - An attempt at modularising the extraction line optics (because we need to change the optics considerably)

Purpose of the extraction line

- The extraction line is the post-collision beamline of the machine, which must satisfy the following conditions
  - Transport the disrupted beam to the beam main beam dump for disposal
  - Transport the nominal beam to the beam dump (with the use of beam sweeping magnets)
  - Transport the beamstrahlung photons to a suitable photon dump
  - All the beam transport must occur with controlled and safe losses in magnetic elements and collimators
  - Provide post-IP diagnostics (? Stripped down version)
  - Provide sufficient separation between the incoming and outgoing beams
  - Allow satisfactory final focus optics in the event of shared magnets for incoming and outgoing beams

The **old** baseline



The baseline is now 14mrad/14mrad (14mrad was derived from the 20mrad and is technological easier and cheaper than the 2mrad)

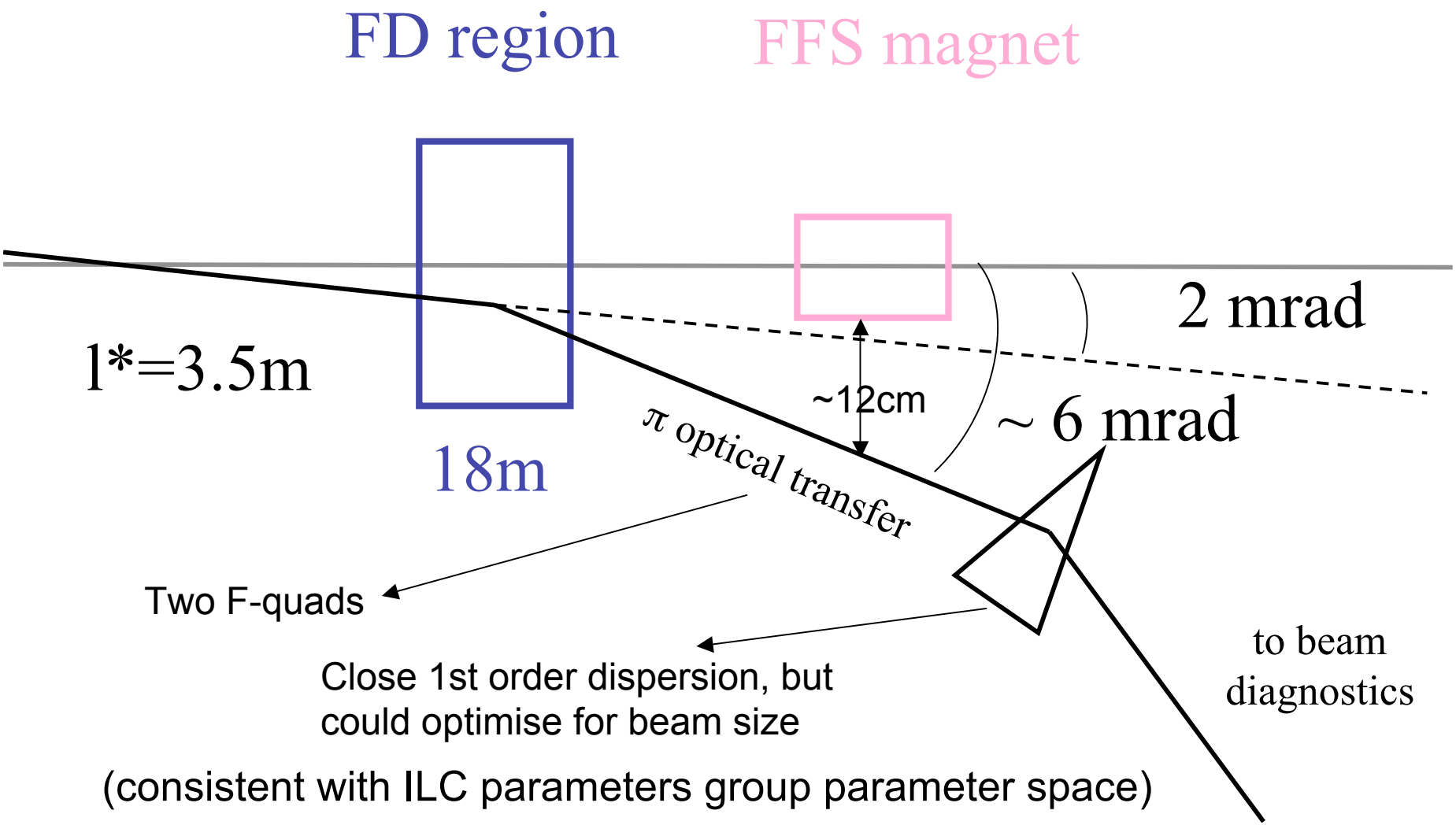
Why is it difficult?

- The beamstrahlung tail (large energy spread) and large angular divergence of the beam causes over-focusing and stronger deflections (~ 1/E) increasing beam size and power losses (Large power means even small losses are bad)
- The shared large-aperture magnets with the final focus are strong, causing strong focusing and large non-linear dispersion of the outgoing, off-axis beam
- Beam size means diagnostics at SF difficult
- Diagnostic and beam separation constraints require horizontal bending, which is difficult to manage due to beam energy spread
- The small crossing angle gives a small beam separation, causing magnet design problems
- Beamstrahlung shares the same aperture as the beam in the early part of the line, requiring large magnet apertures

Snowmass layout

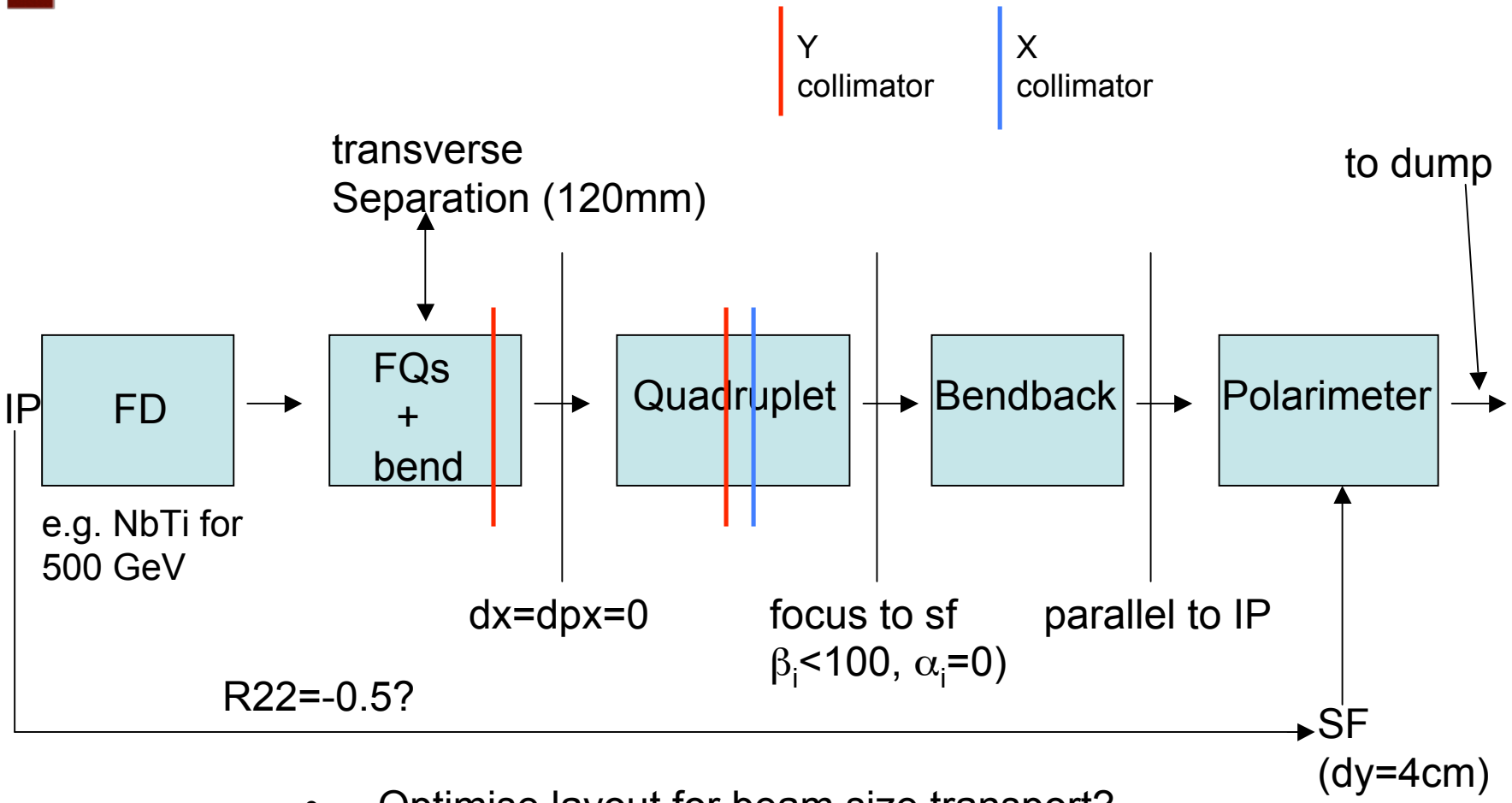
- Developed by 2mrad task force
- Final doublet is shared, and a drift gives beam separation before first extraction line quadrupole
- Extraction line magnets and collimators optimised to reduce beam size
  - Bore sizes derived from beam “fit” + margin
  - Resulting apertures are large…costly
  - Vertical collimation chicane and collimators in early part of line to remove extreme beamstrahlung tail
  - Power losses too high in regions of parameter space
- Key parameter is location of first extraction line quadrupole…move closer and reduce aperture at expenses of beam separation?
- Diagnostics (energy spec. and polarimeter) a considerable complication [removal would reduce cost and ease design]
- Beam transport properties bad for high beamstrahlung parameter

Modular approach in the final doublet region



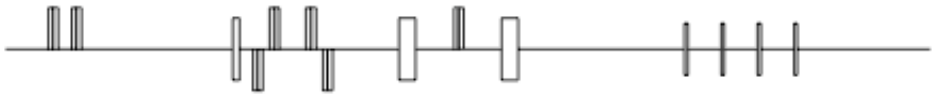
(consistent with ILC parameters group parameter space)

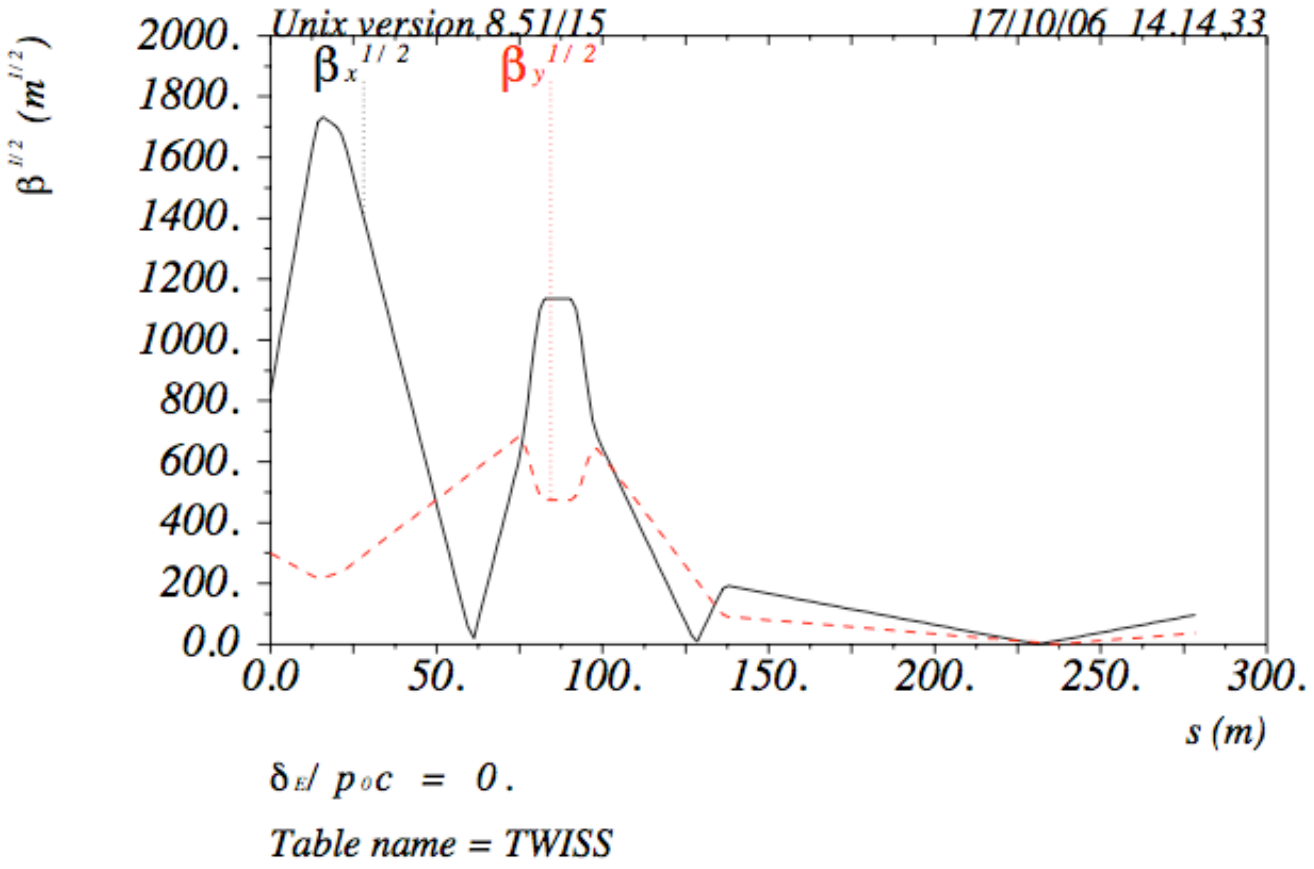
Optics abstraction



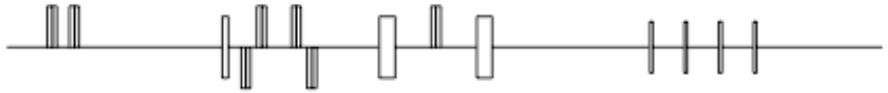
- Optimise layout for beam size transport?
- Concerns are
  1) Transport of higher order dispersion
  2) Beam shape at the SF of polarimeter

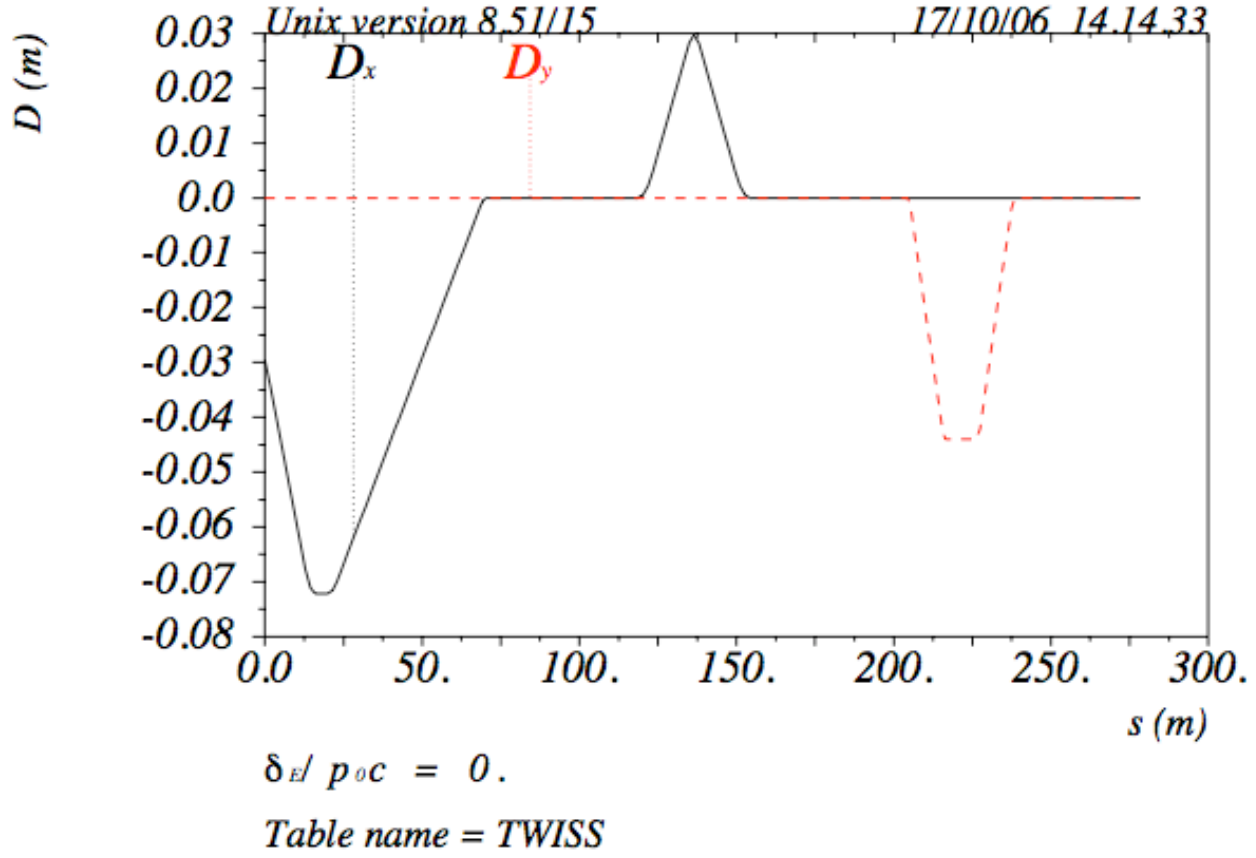
Baseline lattice
Beta functions



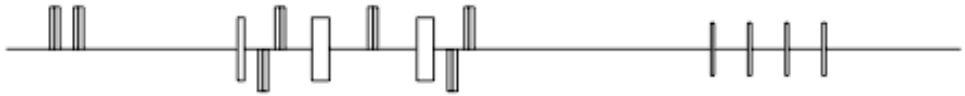


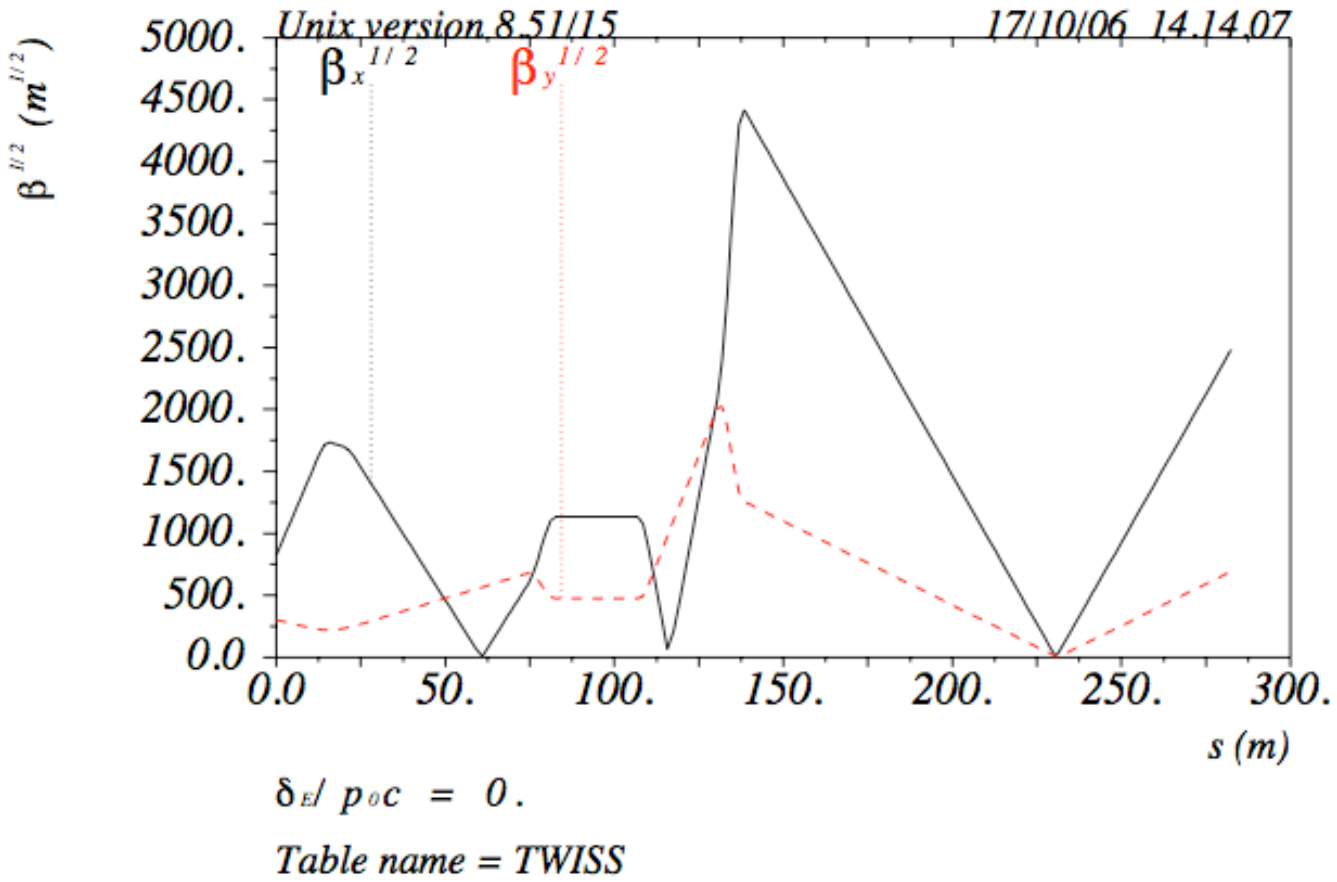
Baseline lattice Dispersion





Reversed structure Beta functions





Conclusions

- The small (and zero) extraction line designs provide considerable technical challenges to beam and magnet physicists
- The Snowmass layout leaves several issues unresolved, including cost and technical feasibility
- An attempt at a new optics was presented, with several attractive features. The magnet apertures will need careful study
- Removing the diagnostics will considerably reduce complexity and cost